The D0 Level 3 Data Acquistion System
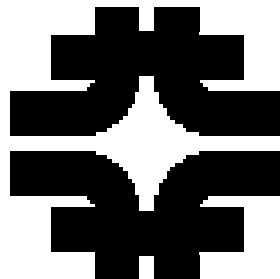
Doug Chapin
Brown Univsersity
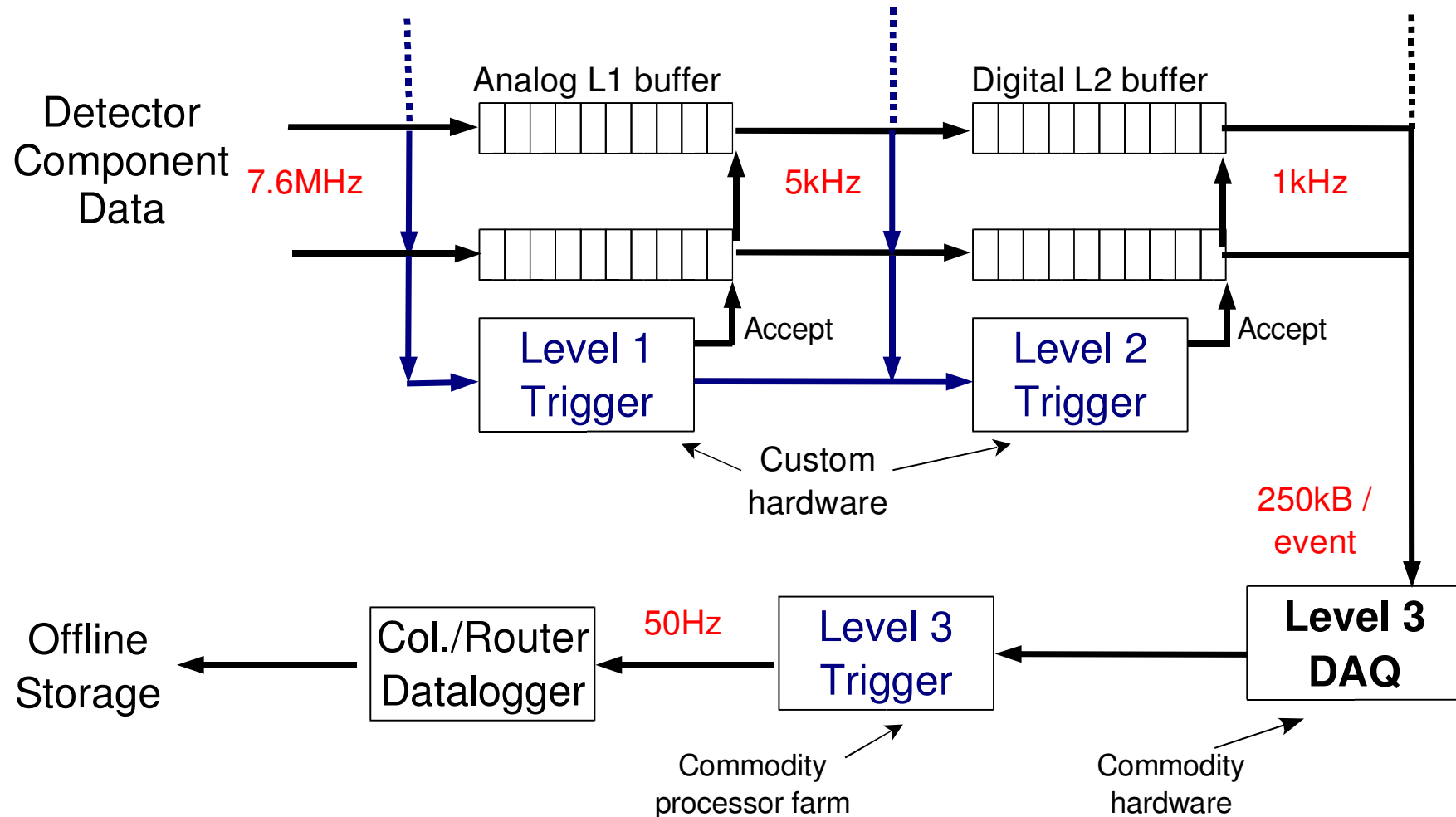
For the D0 L3DAQ Group
Brown University
Fermilab
University of Washington

Outline
- Overview
- Monitoring

D0 Data Acquisition System

Detector Component Data

7.6MHz

Analog L1 buffer

5kHz

Digital L2 buffer

1kHz

Level 1 Trigger

Accept

Level 2 Trigger

Accept

Custom hardware

250kB / event

Offline Storage

Col./Router Datalogger

50Hz

Level 3 Trigger

Level 3 DAQ

Commodity processor farm

Commodity hardware

L3DAQ Requirements

ROC

ROC

ROC

ROC

1KHz   250kB/event

L3DAQ

Farm CPU

Farm CPU

Farm CPU

Collector Router

Total of 63 VME Readout Crates
- 1-10 vme modules / crate
- 1-20kB total / crate / event

L3 Trigger Processer Farm
(currently 82 nodes)

Commodity-Based System

All ethernet TCP/IP

ROC SBC

ROC SBC

ROC SBC

ROC SBC

ethernet concentrator

ethernet concentrator

Gb fiber

100Mb

CISCO 6509 Ethernet Switch

Supervisor CPU

COOR

Routing Master CPU

Global Trigger Framework (TFW)

Farm CPU

Farm CPU

Collector/ Router

Currently 82 farm nodes

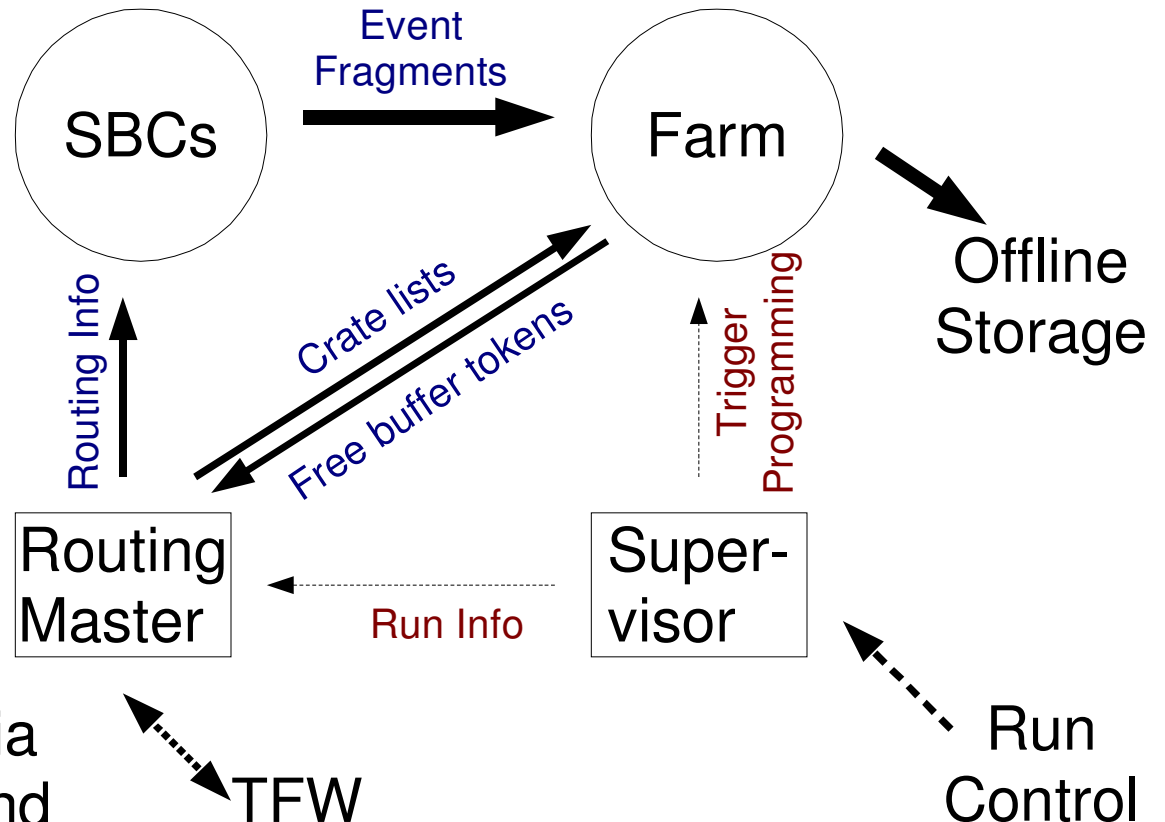SBC=single board computer
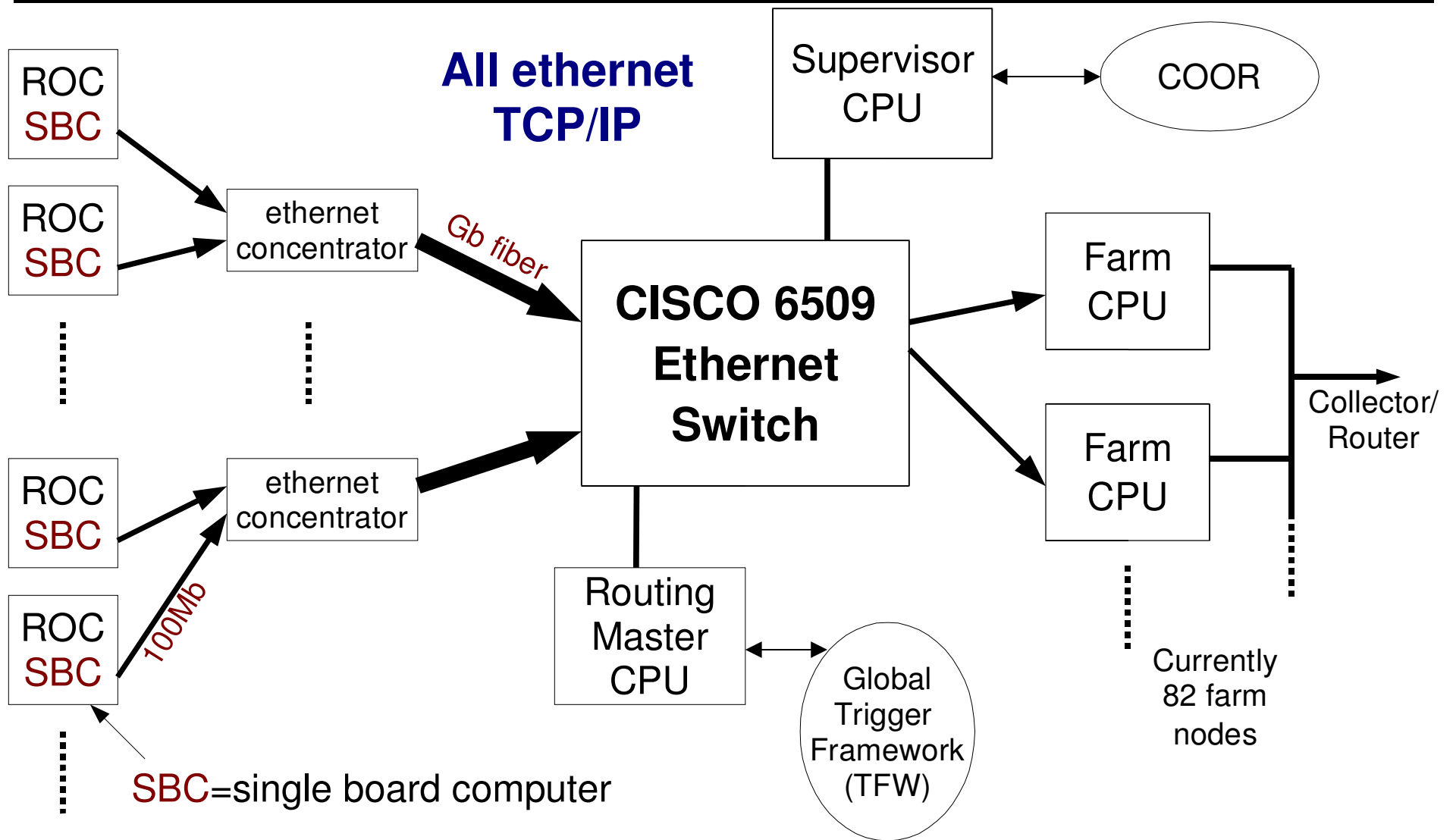
Communication Flow

Features

- Apply backpressure through TFW interface
- Multiple simultaneous runs (D0 requirement)
- Farmnode degeneracy

Software

- Linux
- TCP/IP implemented via ACE communication and utility library
  - Open and multi-platform

SBCs

Event Fragments

Farm

Offline Storage

Routing Info

Crate lists

Free buffer tokens

Trigger Programming

Routing Master

Super-visor

Run Info

TFW

Run Control

Network Switch and Farmnodes

Network
- CISCO 6509
  - Really fast backplane
  - 1MB buffer per output port
- Concentrators
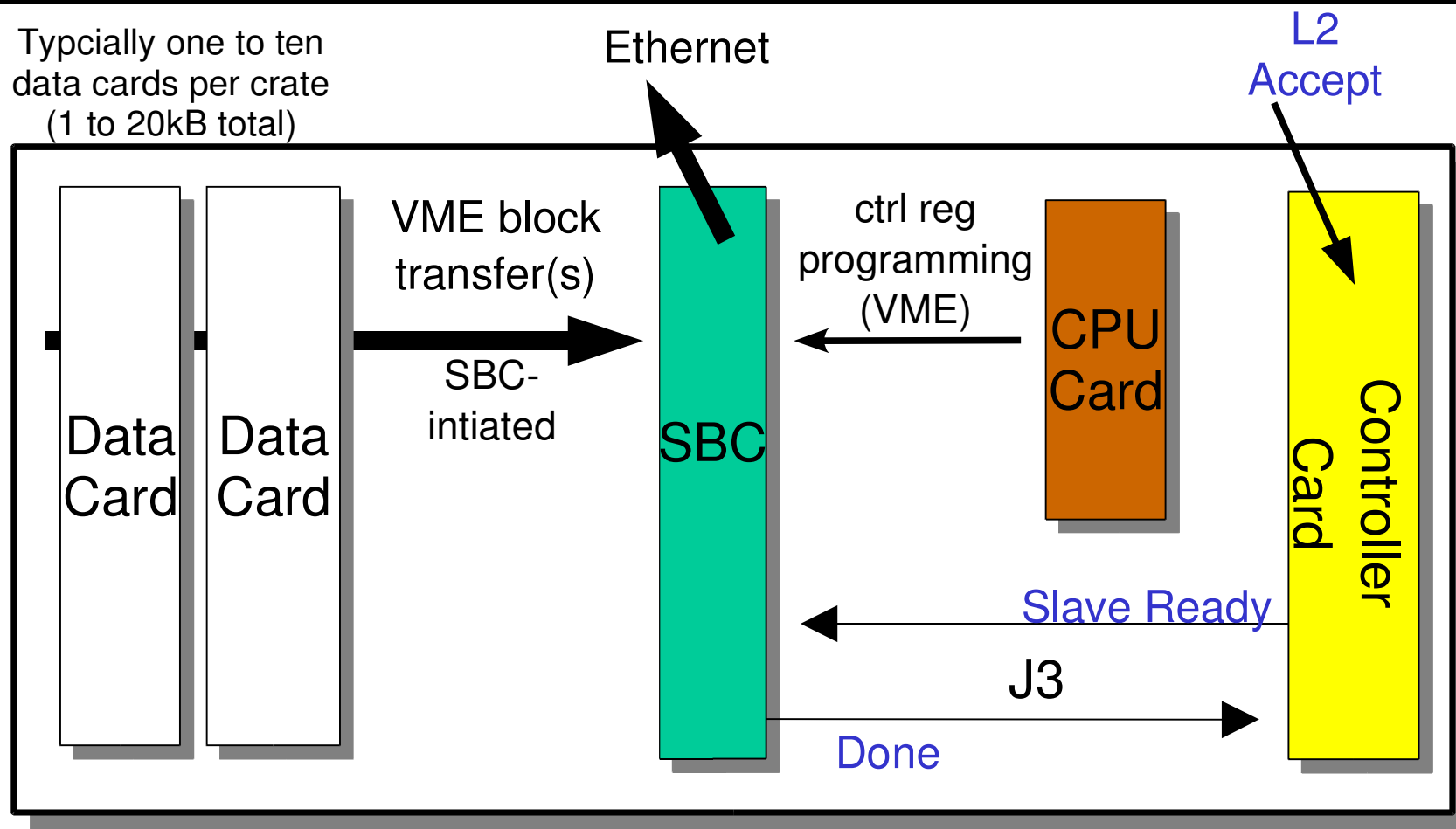 - 100Mb -> Gb fiber
  - 100Mb/s ethernet in SBCs
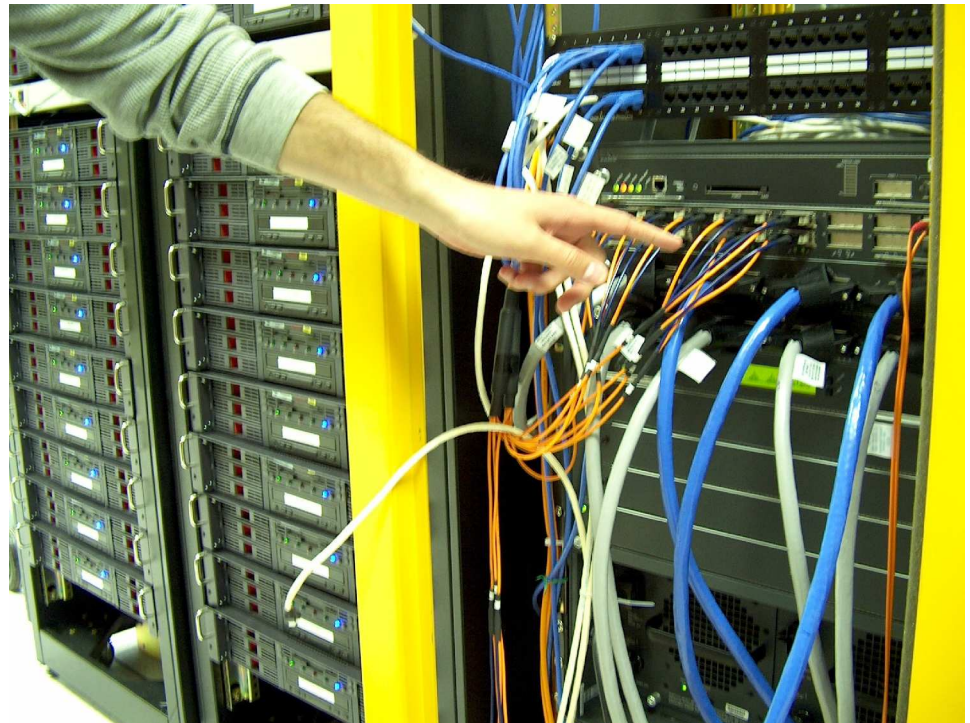
Farmnodes
- Dual Processor
  - AMD 2000 and PIII 1GHz flavors
- Dual ethernet (100MB/s)
  - Connections to L3DAQ switch and Online switch

VME Readout Crate

Typcially one to ten
data cards per crate
(1 to 20kB total)

Ethernet

L2
Accept

Data
Card

Data
Card

VME block
transfer(s)

SBC-
intiated

ctrl reg
programming
(VME)

CPU
Card

SBC

Controller
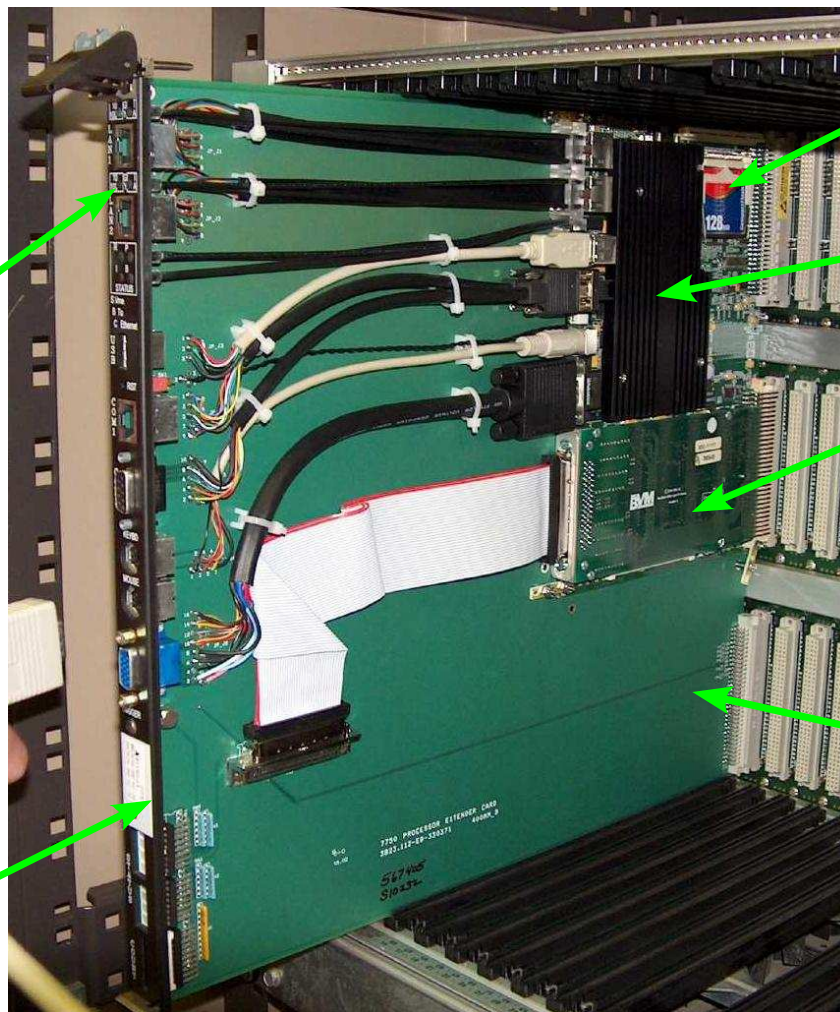Card

Slave Ready

J3

Done

- Data card, CPU, and Controller
  cards specific to crate type

Single Board Computer

VMIC-7750
PIII 933MHz
128MB RAM

Dual
100Mb/s
ethernet
(~24MB/s)

Custom 9U
extender

128MB Flash Disk

Tundra UniverseII
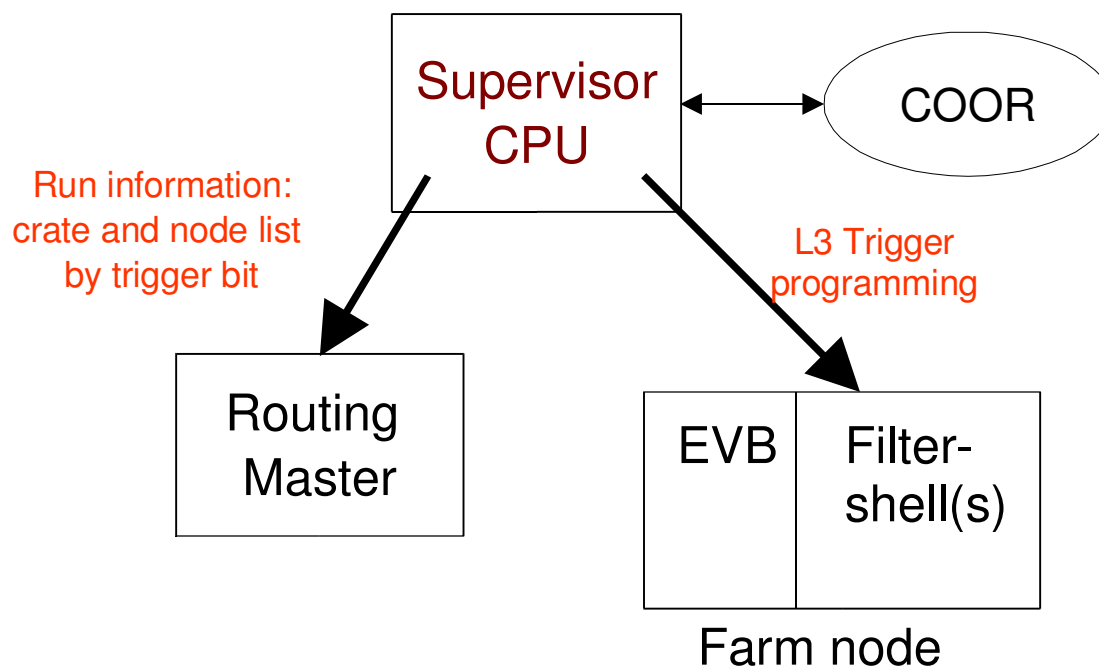PCI<->VME

PMC Digital IO Card

Custom Driver
• IO card
  • J3 handshake
• VME transfers
• Event fragment
  buffering (12MB)

Supervisor Operation

Primary function

L3DAQ interface
to COOR

Supervisor is only active during:
STOP/START
PAUSE/RESUME
DOWNLOAD

Supervisor
CPU

COOR

Run information:
crate and node list
by trigger bit

L3 Trigger
programming

Routing
Master

EVB	Filter-shell(s)

Farm node

- Passes L3 trigger config to Filtershell/Scriptrunner
- Determines which nodes are assigned to a run
- Passes L1/L2 trigger-crate-farmnode association to RM
- No communication with SBC or EVB
- Automatically reconfigures RM/nodes if nodes fail/recover

SBC Operation

Fragment to farmnode

Event Fragment
Queue (50)

Route Queue
(100)

Event fragments
from VME

SBC
Process
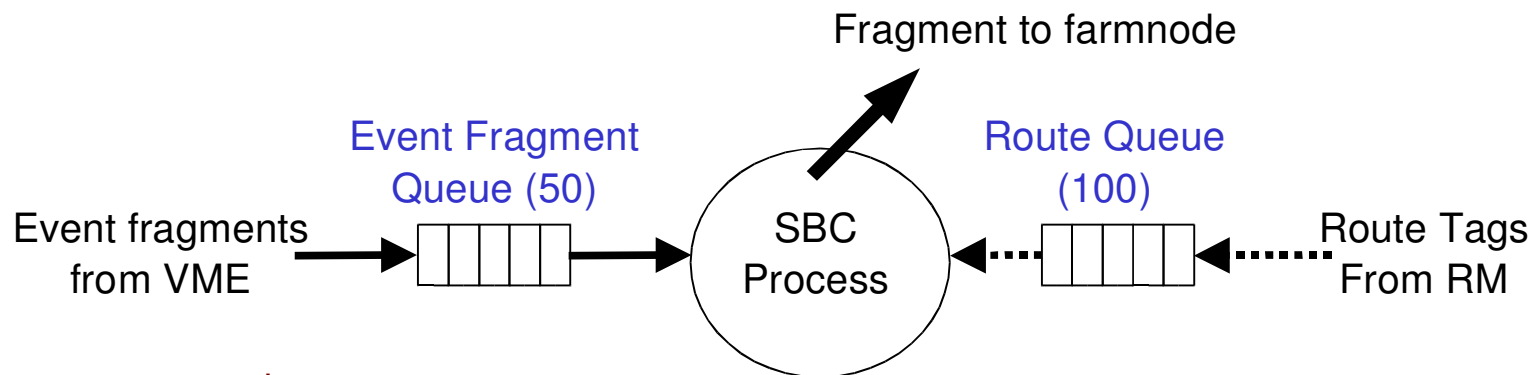
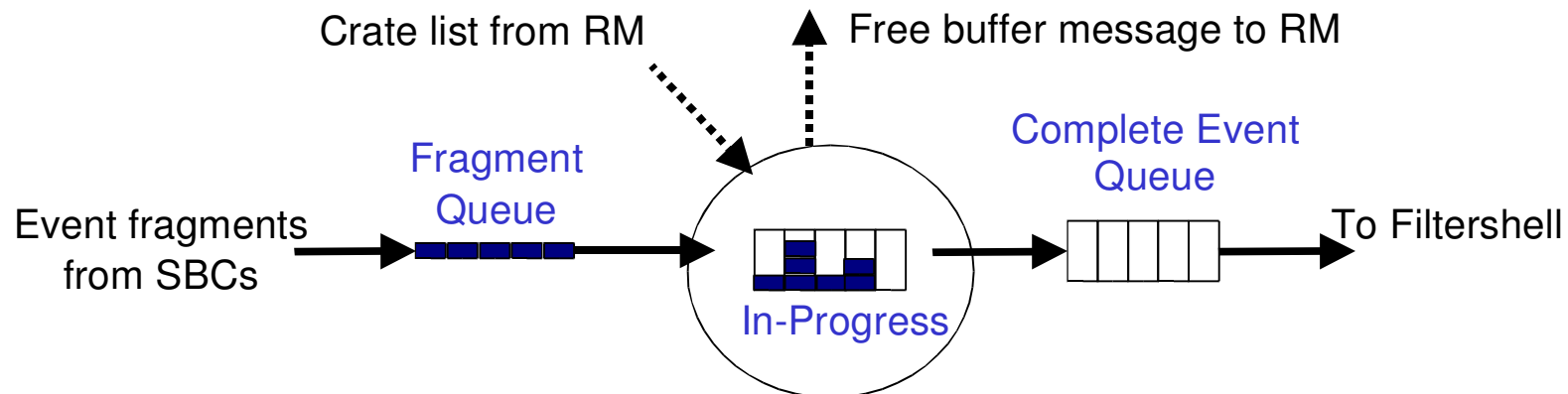Route Tags
From RM

Fragment queue and
VME operation handled
by driver module

Route Tag contains:
- event number
- list of dest. nodes

- Match event numbers in head Fragment and head Route Tag
- Send to appropriate nodes if match
- Discard fragment (or Route Tag) if mismatch
  - Automatic re-sync

EVB Operation

- Fragments combined, keyed on event number
- Expected crate list received from RM
- Event is incomplete after 1sec timeout
  - Associated crates and nodes appear RED in fuMon/uMon
- Free buffer count sent to RM when necessary
  - 20 total buffers, but only max of 3 advertised to RM

Routing Master

Operation
- Dedicated SBC
- Routing decision
  - Based on run configuration and L2 trigger decision
  - Sent to SBCs and target nodes
- Apply backpressure to TFW when too few farmnode buffers

Trigger Framework Interface
- VME cards
- Hardware FIFO
  - Event number
  - L2 accept trigger bit mask
- L1-disable bit registers

Routing Info to SBCs: event# and destination farmnode(s)

Expected crate list to farmnodes

Free buffer tokens from farmnodes

Routing Master

Individual trigger bit disable

Event number/ Trigger bit fired mask

FIFO

TFW Interface
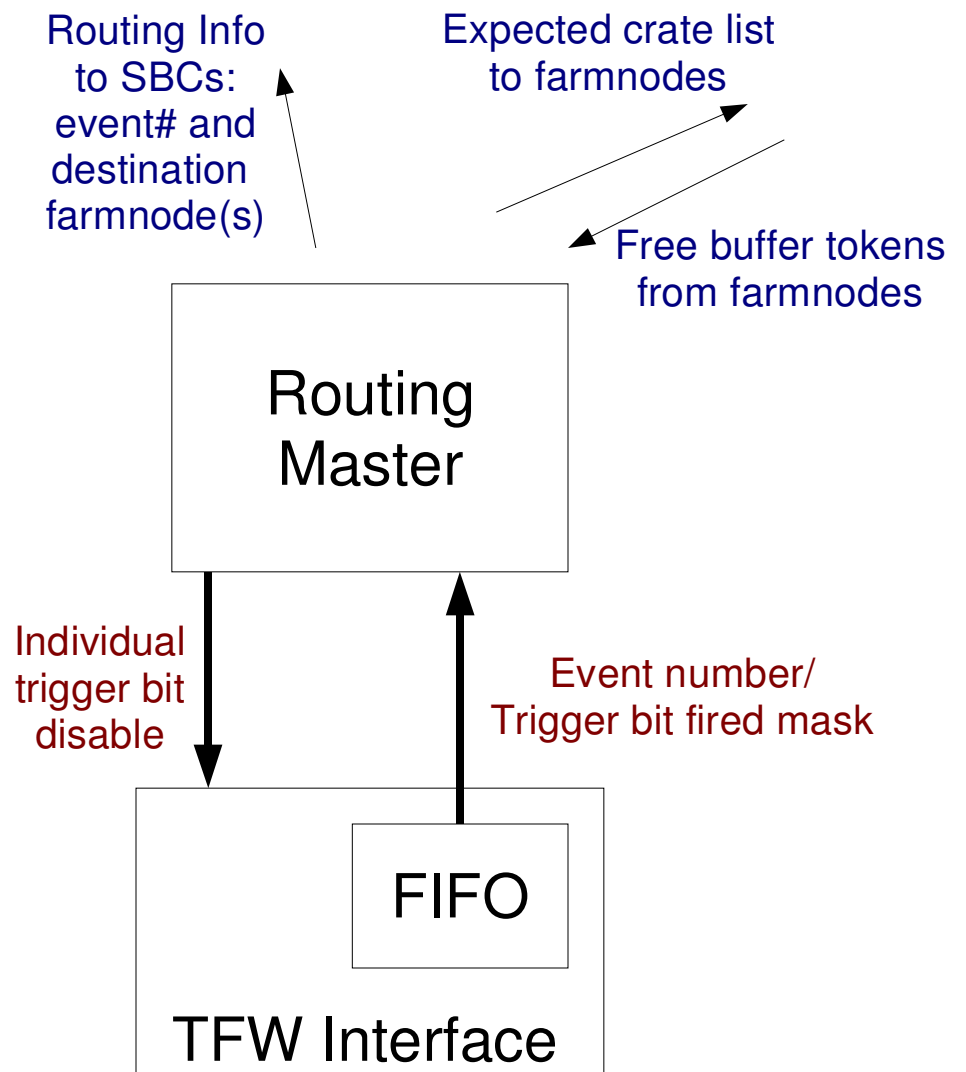
Routing Master Disable Logic

Global Disable
- Disable **all** 128 L1 triggers
  - Even if triggers are in SDAQ run!
- Occurs when RM gets programmed by Supervisor
  - START/STOP/PAUSE/RESUME transitions
  - Usually short (few seconds)

Routing Group Disables
- Disable all L1 triggers associated with a run
  - When <16 total free buffers available on farmnodes in that run
  - Re-enable when >24 buffers available
- Since farmnodes only advertise max 3 free buffers
  - **Your trigger list should assign at least 10 nodes to your run**
    - Exception is CAL calibration run
  - Otherwise disables affect all other PDAQ runs

Event Buffering

Routing Master
- Buffer 10 event tags (routing info) before sending to each SBC
  - Minimize ethernet overhead
    - Without buffering: 63 crates * 1kHz = 60,000 packets/sec

SBC
- Buffers up to 50 event fragments (before routing)
- 10 for RM event tag buffer + 40 for TFW FIFO depth
- Large (1MB) TCP send buffer

Farmnode Event Builder
- 20 buffers (event processing)
- Only send 3 max free buffer tokens to RM
  - avoid overflowing SBC send buffer (max frag size is 256kB)

6509 Switch
- 1MB output buffer per port
- Farmnode TCP receive window set to 10kB
  - 10kB * 80 connections = 800kB (less than buffer size)
  - Avoid dropped packets

Monitoring

Dedicated monitor server
- Pulls info from clients (SBC,EVB,RM) and caches it

Main shifter displays
- **uMon**: SBC and RM info
- **fuMon**: EVB and some Filtershell info
- Common color scheme
  - Red: incomplete events
  - Yellow: no monitoring information
    - crashed process?
    - Network problem?
  - White: OK

Read the help webpages for uMon and fuMon
uMon even has a help button

üMon v2.6.00

dzero Data Acquisition Über Monitor

L3 Input/Incomplete Event Rate
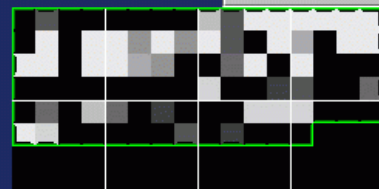(1 KHz Scale)   1 KHz Scale ▼

9:56:01 PM   10:27:40 PM

L3 Input Rate
384 Hz

0x10 Inc%:0	0x11 Inc%:0	0x12 Inc%:0	0x13 Inc%:0
0x14 Inc%:0	0x16 Inc%:0	0x17 Inc%:0	0x18 Inc%:0
0x19 Inc%:0	0x1f Inc%:0		

| 0x20 Inc%:0 | 0x21 Inc%:0 | 0x22 Inc%:0 | 0x23 Inc%:0 |
| 0x24 Inc%:0 | 0x25 Inc%:0 | | |

0x30 Inc%:0	0x31 Inc%:0	0x32 Inc%:0	0x33 Inc%:0
0x34 Inc%:0	0x35 Inc%:0	0x36 Inc%:0	0x37 Inc%:0
0x38 Inc%:0	0x39 Inc%:0	0x3a Inc%:0	0x3b Inc%:0

0x40 Inc%:0	0x41 Inc%:0	0x42 Inc%:0	0x43 Inc%:0
0x44 Inc%:0	0x45 Inc%:0	0x46 Inc%:0	0x47 Inc%:0
0x48 Inc%:0	0x49 Inc%:0	0x4a Inc%:0	0x4b Inc%:0
0x4c Inc%:0			

| 0x50 Inc%:0 | 0x51 Inc%:0 | 0x52 Inc%:0 | 0x53 Inc%:0 |

0x60 Inc%:0	0x61 Inc%:0	0x62 Inc%:0	0x63 Inc%:0
0x64 Inc%:0	0x65 Inc%:0	0x66 Inc%:0	0x67 Inc%:0
0x68 Inc%:0	0x69 Inc%:0	0x6a Inc%:0	0x6b Inc%:0

| 0x70 Inc%:0 | 0x71 Inc%:0 | 0x72 Inc%:0 | 0x73 Inc%:0 |
| 0x74 Inc%:0 | 0x75 Inc%:0 | 0x79 Inc%:0 | 0x9? Inc%:0 |

L3 Input Rate By Bit
Bit 0: 0.3 Hz   10 Hz Scale ▼

Route FIFO Depth   RM-Farm conn

Global L3 Disable: 0.0%

EVB Rates   10 Hz Scale ▼

Node 25: 4.7 Hz

Reset Inc Counters

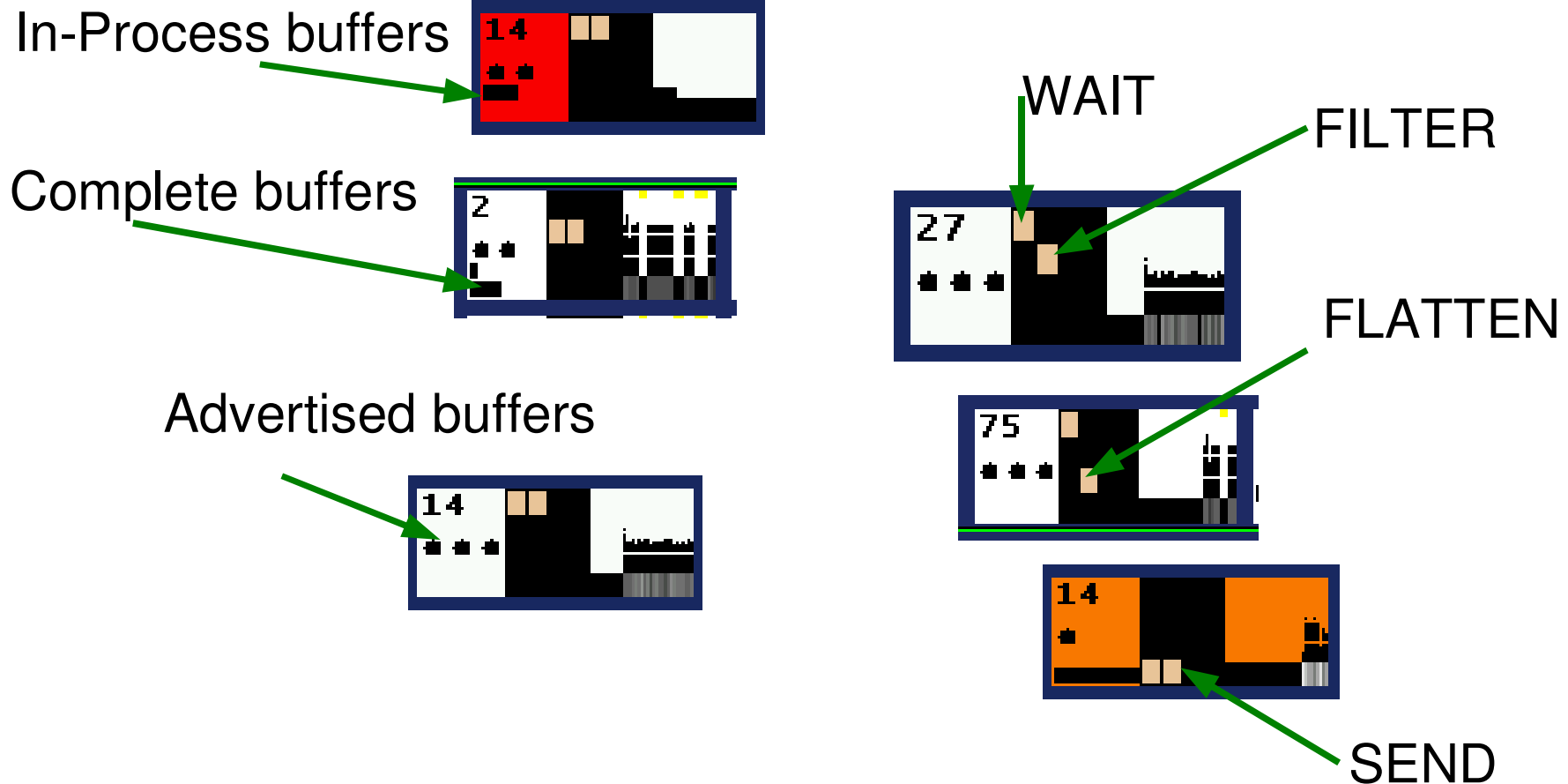UNreset Inc Counters   Help

Routing Group 0

Input: 369 Hz

Disable: 0.0%

Total EVB Rate
369 Hz

Super Status: Ready

Data Refresh

füMon v1.0.01

Node 16 Details
Run 176930   CPU: 35%
In: 4.3Hz   IP: 0   AD: 3
Out: 0.3Hz   COM: 0   FB: 20
<188k>   EQ: 0
                FS[0]   FS[1]
Total   54333   54331
Failed   49441   49513
Passed   4892   4818
Sent   4892   4818
SendErr   0   0
StopReqs   8   8
Restarts   9   9
Exits   0   0
State   WAIT   WAIT

Refresh <5.1s>

10Hz

1 Run
Run 176930

Out/Pass (Reject)   100Hz
36Hz/10% (9.6)

CPU Utilization

0   20   40   60   80   100

dzero   L3DAQ Farm Über Monitor

fuMon Details

In-Process buffers

14

Complete buffers

2

WAIT

FILTER

27

Advertised buffers

14

FLATTEN

75

14

SEND

Documentation

Please read the fuMon and uMon documentation on the L3DAQ webpage

L3DAQ Webpage

http://d0ol/www/groups/l3daq/

- What-to-do-When (WTDW)
  - Common problems and solutions
- Logfiles for SBCs
- uMon and fuMon documentation (read these!!!)
- SBC Manager Page
  - Reset SBCs at the click of a button

Common Scripts

l3xdaq_reset
- Restart SBC processes (and RM)

l3xreset / l3xstop
- Restart / stop EVB and Filtershell processes
- l3xstop useful for removing flaky nodes

More at the WTDW page

Summary

D0 L3DAQ is best operating DAQ in HEP?

Please
- Visit the webpage
- Read uMon and fuMon documentation
    - Phone Doug or Mike with questions
- Read WTDW **before** encountering common problems
- Email general suggestions/complaints to d0daq@fnal.gov